Team SEA TRIDENT
University of Houston College of Technology

Team Members:	**Mentors:**
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Abstract

Team Sea Trident is designing and building an ROV to compete in the MATE 2012 ROV competition. This report demonstrates in depth research and calculations. In addition, this report illustrates components that were researched and the selections that have been made. The team will create an electric propulsion system with a hydraulic system to control one manipulator that will be attached to the ROV. The frame will be composed of HDPE (High Density Polyethylene) material due to its high density. The team will build two watertight systems to house the hydraulic system and the electronics for the propulsion.

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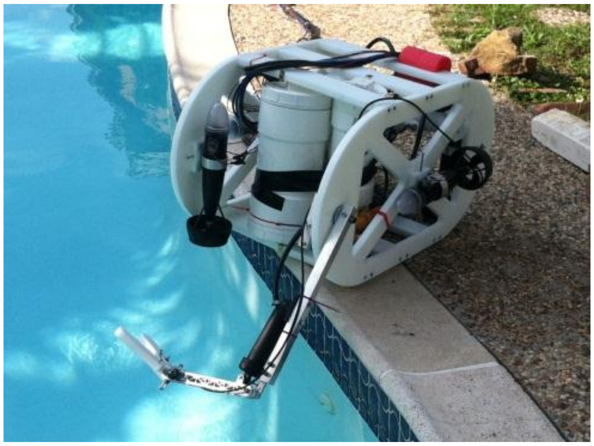
Photograph

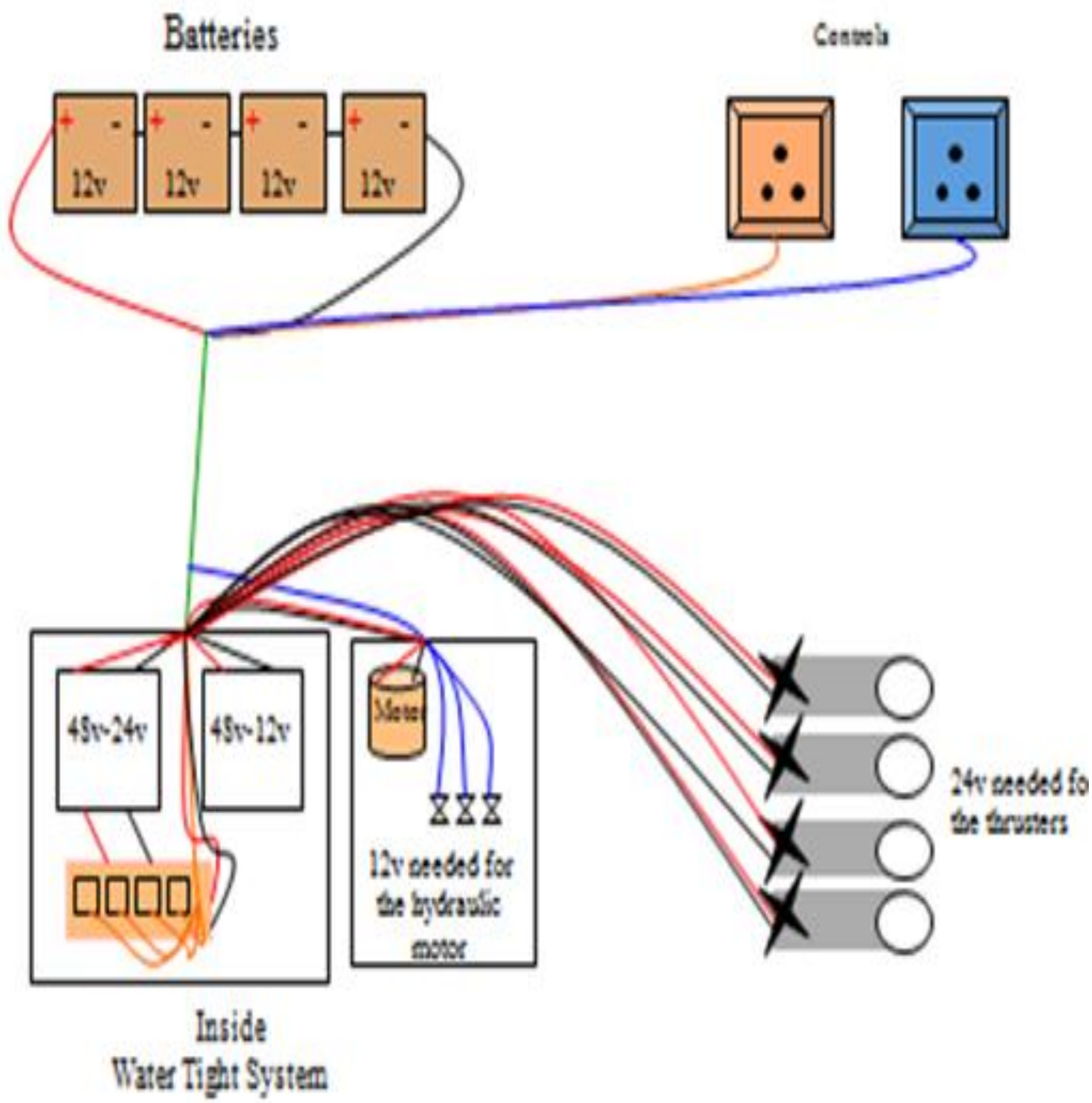


Budget/expense sheet

Budget:	**$2,500.00**
HDPE	$292.02
Watertight System	$44.92
Wooden Frame	$30.00
(2) Thrusters	$1,115.00
(2) DC/DC Converters	$66.84
Controller/H-Bridge	$483.14
Competition Fee	$50.00
Converter	$93.22
Camera	$146.00
Category 5 Wire	$100.00
Batteries	$49.56
Balance:	**$29.30**

Donated items were the hydraulic system by Insta-trim.

Electrical schematic



Design rationale

Team Sea Trident is designing and building an ROV that will consist of an electrical propulsion system and a hydraulic system that will control one manipulator that will be attached to the ROV's frame. The limitations for competition were the following:

Power Source

Team Sea Trident will use the following guide lines to select a power source.

- *Voltage*: nominal **48 volts** DC.
- *Current*: the amperage may never exceed **40 amps**.
- *Connections*: Power supply connections will be via terminal posts, a ¼" bolt with a wing nut. We should have proper cable-lugs with ¼" ring connectors for these posts to have power.

The power source will have to be able to power the electric loads required by the ROV throughout the competition with it possibly being exposed to water.

In order to achieve this, the following calculations were used to determine the following:

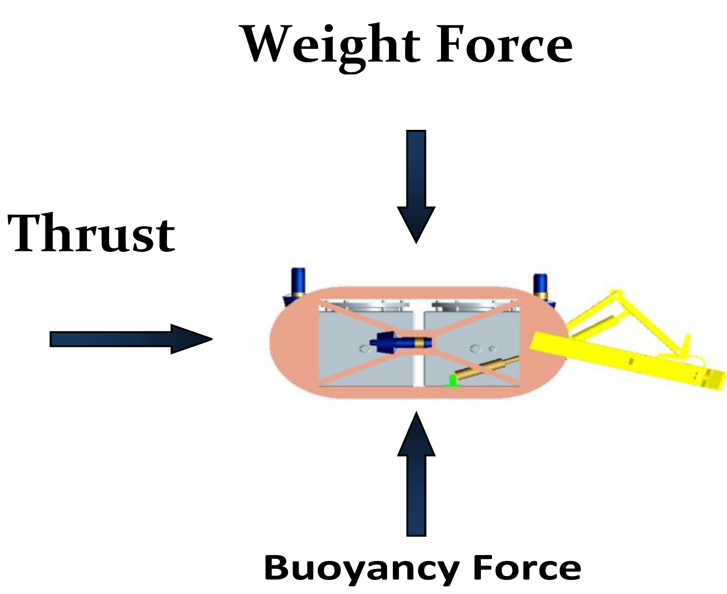


Figure 19

Frame Design

Achieving a positive neutral buoyancy state is most critical part of the design. Figure 19 shows how the forces will act will determine if the ROV will float. Another factor that must be considered is the frame material, all the components will be attached to the frame and therefore, a dense material should be selected for the design. Through research, team sea trident determined that high density polyethylene material is the lightest material between PVC and Aluminum. Therefore HDPE will be the best material to utilize for this project due to its density and anti-corrosion properties. The team decided to create the frame out of HDPE material, figure 21 illustrates the frame design the team has put together.

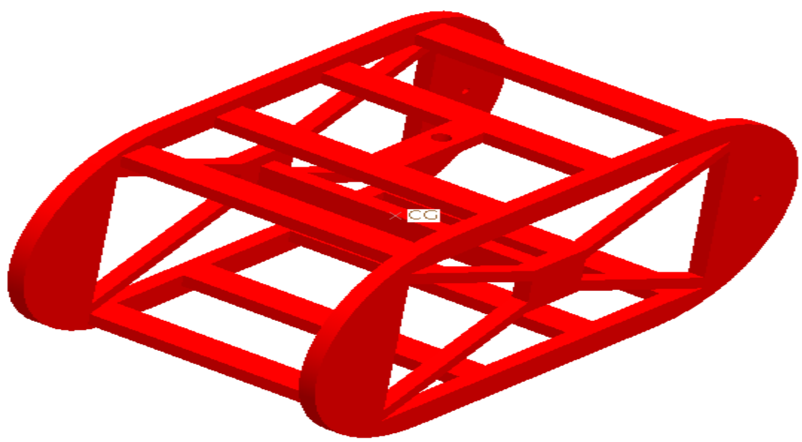


Figure 21

Dimensions	**Weight**
86cm x 47cm x 61cm	***4.5 lbs.***

Figure 22

Buoyancy:

For neutral buoyancy the following equation must be used.

$$\sum F = 0 = F_{Device} - W_{Device}$$

The sum of the forces applied to the ROV and the weight forces should be equal to buoyant force applied by the water. The density of the fluid is a big factor on how the forces will act on the ROV. Also, another important aspect that will determine the success is the determination of the center of gravity of the ROV. This cannot be calculated until the components are decided upon. Once the ROV reaches neutral buoyancy we will be able to manipulate it through thrusters.

Calculations to find displacement volume that will make ROV neutrally buoyant

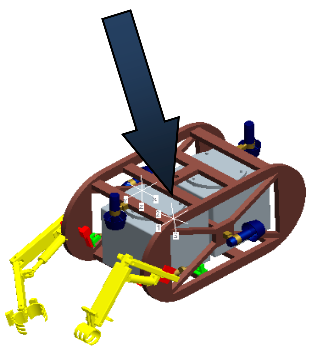


Figure 28

Buoyancy Calculations

$F_{Rov} = Mg$ $F_{Rov} = 667N$	$F_{Rov} = Weight\ of\ Rov$ $M = mass$ $g = gravity$	$M = 68\ kg$ $g = 9.81\ \frac{m}{s^2}$
$F_w = \rho g v_{WD}$ $F_w = 999 * 9.81 * 1$ $F_w = 281.26N$	$F_w = force\ of\ water$ $\rho = desity$ $g = gravity$ $v_{WD} = volume\ displaced$	$g = 9.81\ \frac{m}{s^2}$ $\rho = 999\ \frac{kg}{m^3}$ $g = 9.81\ \frac{m}{s^2}$ $v_{WD} = .0287\ m^3$

Figure 29

Based on the previous calculations the team determined that the ROV will sink. In order to make the ROV neutrally buoyant the team will add a volume $of\ \ \boldsymbol{v_{Rov}} = .03936\ m^3$ in order to achieve this volume, the team will add syntactic foam. This will make the total displacement volume of .06806 m^3.

$F_{Rov} = Mg$ $F_{Rov} = Weight\ of\ Rov$ $M = mass$ $g = gravity$ $M = 68\ kg$ $g = 9.81\ \frac{m}{s^2}$ $F_{Rov} = 68 * 9.81$ $F_{Rov} = 666.4\ N$ $neturally\ boyant\ when\ F_{Rov} = F_w$	$F_w = \rho g v_{WD}$ $F_w = F_{Rov}$ $\rho = desity$ $g = gravity$ $v_{WD} = volume\ displaced$	$F_w = F_{Rov}$= 666.4 N $\rho = 999\frac{kg}{m^3}$ $g = 9.81\ \frac{m}{s^2}$ $v_{WD} = \frac{F_{Rov}}{\rho g}$ $v_{WD} = \frac{666.4}{999 * 9.81}$ $v_{WD} = .06806\ m^3$

Is the total volume needed to be displaced in order make the ROV neutrally buoyant currently the ROV displaces $.0287\ m^3$ so this means that the team must inclease the volume displacement of the ROV by $.0393\ m^3$.

Propulsion

The propulsion is the thrust required to achieve movement of the ROV. The team's goal is to make ROV have a velocity of .5m/s. The team did the following calculations to determine what kind of power we need on the thruster.

Initial conditions include;

ROV weight 150 lbs.

$$C_D = 1.05 \qquad \rho = 999\frac{kg}{m^3} \qquad v = .5\frac{m}{s} \qquad A = .2787m^2 \qquad C_D = drag\ coffecient$$

Drag coefficient that is used is based on that the ROV is squared in the front. Using the information, the team determined that the ROV has an area of 0.2787m2, and taking in consideration that the water will have a density of .999 kg/m^3 the team determined the following:

Pressure drag	Variables	*Known*
$F_d = C_D(\frac{\rho v^2}{2})A$	F_d = pressure drag	$C_D = 1.05$
$F_d = 1.05\left(\frac{999*.5^2}{2}\right).2787$	C_D = drag coffecient	$\rho = 999\frac{kg}{m^3}$
$F_d = 8lb$	ρ = desity of liquid	$v = .5\frac{m}{s}$
Force needed per thruster	v = velocity	$A = .2787m^2$
$F = 4lb$	A = area	
	F_d =?	

Based on the previous calculations the team determined that the ROV must overcome an 8lbf. in order to propel the ROV thru the water. This means that each thruster must be rated at a minimum of 8lbf. Based on this information the team decided to place two thrusters in parallel to divide the force into 4lbf per thruster, to propel the ROV. These calculations are the basis of choosing thrusters.

Hydraulic System (Initial System)

A Basic hydraulic system consists of an electric power supply which powers an electric motor. This electric motor converts electric energy to rotational energy that is transferred through the shaft to a hydraulic pump. The hydraulic pump takes the hydraulic fluid from the reservoir tank and pressurizes it to a desired pressure. The hydraulic fluid is then routed through hydraulic lines to a hydraulic motor where is converted to rotational energy. The rotational energy will be converted in to propulsion. The formulas on figure 11 are going to be used to figure out the energy to propulsion force are the following:

	Formulas
Electric Power Supply (Battery)	**Cp=(I^k)*t** Cp = discharge rate,(A*H) I = actual discharge current (A) t = actual time(h)
Electric Motor	**HP(output)=** $\frac{\mathbf{I \times E \times Eff}}{\mathbf{746}}$ HP = Horsepower I = Amps E = Voltage Eff = Efficiency
Hydraulic Pump	**HP(input) = (Q ×P) / 1714 × E** Hp = Horsepower Q = Flow rate (GPM) P = Pressure (psi) E = Efficiency

Figure 11

Figure 12 below illustrates a basic hydraulic system, discussed on the previous page.

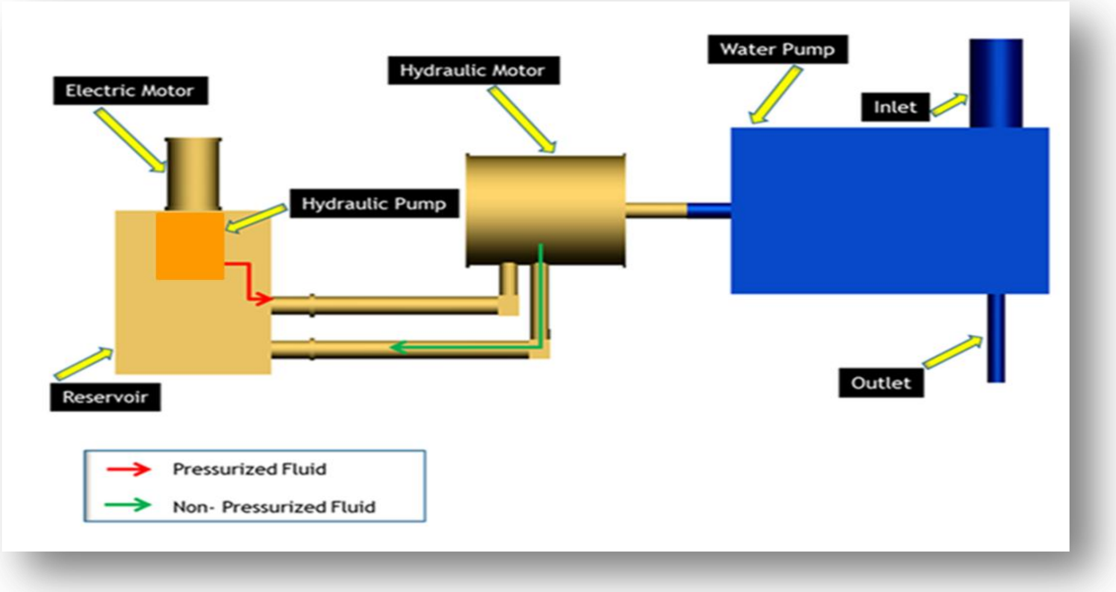
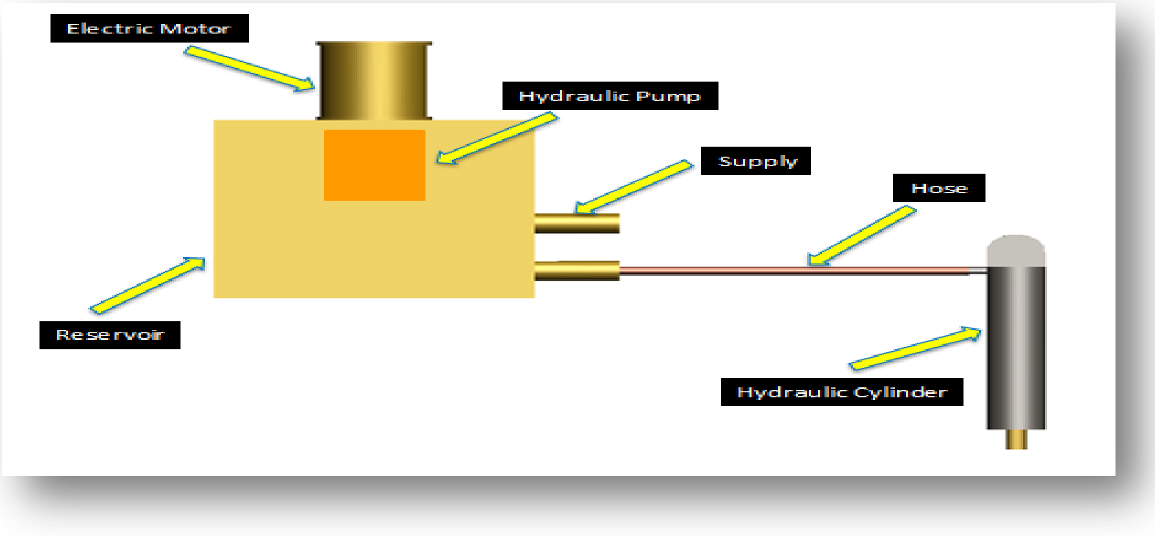


Figure 12

Based on research and the team's industry advisors recommendation, team sea trident determined that it will be more efficient to create the hydraulic system to power only the manipulators, and an electric propulsion system to power the ROV. Having an all electro hydraulic propulsion system will cause energy drops in every transition between components, this means that the hydraulic system will lose approximately 50 % of the initial power used for propulsion. On the other hand, using the electric propulsion system allows 80% use of the power, which means the electric system, is about 30% more efficient than the hydraulic system. In addition, the hydraulic system increases the chances of having a leak in the system, causing the team to lose points at the competition.



Component Selection

Complete 24 Volt Motor Pump Unit with Tees for 4 Cylinders & Hoses

www.istatrim.com

Volt: 24 V

Pressure: 400psi

Dimensions: 11” Length, Width 8”, Height 11”

Price: $390.00

Hydraulic Pump Unit

The hydraulic pump unit will be used to provide pressured hydraulic fluid to the arms for movement. The hydraulic pump unit must be able to work with a maximum pressure of 150 psi. The hydraulic unit must capable of providing 150 psi of pressure using 24V. It must be able to handle a minimum of 6 cylinders being capable of operating 3 at one time.

Biodegradable Hydraulic Oil ISO 46

Price: 46.00
Source: http://baar.amazonwebstore.com

Hydraulic fluid viscosity needs to be considered when being selected because it will affect the performance of the system. We have to ensure the system will be able to handle the low pressure. To compete, the fluid must be biodegradable and approved by the MATE rules and regulations.

Valves

Solenoid Valve with Green Wire

www.insta-trim.com/pap.html

Volt: 24 V

Pressure: 4,000 psi

Dimensions: 2.0” Length, 3.5” Height

Weight: .5 lbs.

Price: $65.00

Solenoid Valve

The solenoid valves will be used to control the hydraulic cylinders. The actuators will get their signal from the DAQ board. This signal will allow the hydraulic fluid to be introduced into the hydraulic cylinder allowing the arms to move. The specifications this solenoid valves have to be rated at a minimum of 150 psi., must be able to work with 24V.

Thrusters

The thrusters will be used for propulsion of the ROV. The thrusters must be able to operate at 12V while providing a minimum of 15 lb. of propulsion force per the calculation. There will be 4 thrusters that will be used; two will be used for forward and back movement. The other two will be used for lateral movement.

Hydraulic Cylinders

The hydraulic cylinder will be used to move the arms. There will be 3 cylinders per arm. They must meet the following specifications to be able to operate with maximum hydraulic pressure of 150 psi. They should be able to lift a minimum of 5 lbs. and must be compatible with the hydraulic unit connections.

Hydraulic Cylinder with Hose with Sensor for Systems with Tab Locators

istatrim.com

Volt: 24 V

Pressure: 4,000 psi

Dimensions: 9” Length, Diameter 1.5”

Weight: 2 lbs.

Price: $137.00

Challenges

The challenges that our team faced constantly was finding the time to meet and work on the project as a team. The other big challenge was figuring out the electrical system because everyone on our team is a mechanical engineer student.

Troubleshooting technique:

The technical problems we had were making the water tight boxes water tight. We overcame this by sealing one end of the PVC pipe at a time to determine which side was leaking. Another problem that we ran across was figuring out how the connect the electrical system we overcame this problem by using an amp meter to determine what wires went were.

Skills gained

The team learned how to use an amp meter and how to read electrical diagrams and why amps and volts are important.

Discussion of future improvements

Future improvements would be figure out a better watertight system because it failed due to the strain in the wires in between the watertight boxes.

Reflections on the experience

This whole project was frustrating at times for everyone in the team but when we got it working for the first time after spending all night working on it. It was definite worth it. It would also have helped if we did not leave everything for last minute.

References

www.bestmaterials.com	www.materover.org	www.bhphotovideo.com	www.ni.com
www.drillspot.com	www.grainger.com	www.buy.com	www.technadyne.com
www.onlinecomponents.com	www.doitbest.com	www.harborfreight.com	www.crustcrawler.com
www.robotshop.com	www.seaviewer.com	www.homedepot.com	www.maxim.com
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Acknowledgements